SWIMMING POOL OPERATION[1]

By Jack J. Hinman, Jr.

Swimming pool operators are naturally desirous of making the use of the swimming pools under their control as pleasant and as safe as possible for those who use them. The swimmer thinks first of the convenience and appearance of the pool and its appurtenances, and of the temperature, clarity, odor and taste of the water. If these are satisfactory he is inclined to assume that the water is safe for use. In the design of pools at the present time more thought is given to convenience and appearance than was given in the past and a great deal more consideration is given to the devices which insure a safe water in the tanks. Fewer pools are now located in dark basement rooms, while more and more pools are constructed with plenty of provision for light, thus insuring greater attractiveness as well as better sanitary conditions.

Design. A swimming pool should be constructed so that it can be kept clean easily. The tank should be watertight, of course, with walls of brick, stone or reinforced concrete, and it should have a smooth lining of enameled tile or similar material. All corners should be rounded to make cleaning easier. There should be no unnecessary obstruction of the sides by hand rails, steam pipes or other fixtures. The combined hand rail, expectoration and overflow trough should be used, and should extend entirely around the tank. It is well to give the bottom of the tank a kind of hopper-shape so that the deepest part of the pool may be where men from the diving board or platform will enter the water. The drain-pipe of the pool should be large. It should never be less than 4 inches in diameter. This will prevent an unnecessary waste of time when the pool is emptied. In some places quick-emptying devices are provided in case of accident.

The pool water should enter through orifices near the surface

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at the shallow end of the pool and be withdrawn through openings at the lowest part of the deep end. There should be sufficient force in the stream of incoming water to cause a distinct current. In this way sediment and floating matters are carried toward the outlet and the polluted water is most effectually removed or diluted. Wherever the water removed from the tank is constantly purified and returned or the process of continuous addition of water is used, this manner of adding the water will be found most effective in removing objectionably polluted water and sediment.

The best method of heating water, especially where filters are used, is by means of coil heaters before the water is passed through the filters. Where waters of high carbonate hardness are used, the addition of steam drives off much of the free and half-bound carbon dioxide with the production of turbidity in the pool. The filters will retain this material although there is a greater tendency toward cementation of the sand bed as a result. The type of filter best adapted to this work is a pressure mechanical filter. It should be provided with a manual agitation device as well as arranged to wash the filter medium by a reverse flow of pool water. The purpose of the manual agitator is to provide a positive means of preventing undue cementing processes. Filters of the pressure type may be insulated by asbestos and so save a considerable portion of the heat which has been given to the water. The operation of filters and the treatment of the water will be discussed in greater detail below.

The path around the pool should be wide enough to permit two people to pass easily. The cement or tile of which it is made should be pitched away from the pool to avoid water running back and increasing the contamination of the pool water.

Convenient toilets with entrances to the pool room should be provided. The easier they are of access the less will be the urinating in the pool and the less the contamination from such source.

The importance of shower baths is generally recognized. However, it is hard to have efficient supervision over the bathing. If suits are worn the shower-bath should be taken before the suits are put on. This requires a sort of private bathing booth for each individual's use. In Y. M. C. A. pools and men's pools where no suits are worn, the shower bath may be taken before the instructor or attendant who can then see that the bath is sufficiently thorough. These showers may be conveniently situated in the pool room itself.

The presence upon the platform of the pool, of visitors wearing street shoes, is objectionable since they carry dirt into the room. This in turn may be carried into the pool upon the feet of the bathers. In order to avoid this, as well as to allow a better view of pool activities, galleries for visitors are very desirable.

The advantages of a well-lighted room were mentioned above. The attractiveness is much increased if the ceiling is very high, two stories in the clear, with the visitor's gallery located at the level of the floor above.

The walls of the pool room should be made of some smooth washable material, such as white tile. Any wall or ceiling finish which is attacked by moisture should be avoided, since the air will be water-saturated most of the time and sweating may produce stains of rust, etc.

Use. It is a well-known fact that upon our bodies there are vast numbers of bacteria most of which are probably harmless. Since the number of these bacteria varies inversely as the care with which we keep our bodies clean, it readily follows that the cleaner the users of the pool the less the pollution of the water if it is used by the same number of swimmers. Bunker and Whipple (1) say that a dirty hospital patient was found to have upon his body 25,000,000,000 bacteria, while a man of clean habits and smooth skin had 3,000,000,000 and a man of clean habits whose skin was hairy harbored 14,000,000,000.

The shower bath taken before entering a swimming pool should be a thorough one as has been mentioned before. It should be taken with warm water and soap, and if possible, should be supervised by an attendant. The soap should be provided, otherwise its use may be omitted altogether. Plenty of soap should be used and care should be taken to see that the hair (unless rubber caps are worn) and the entire body are well washed. As was mentioned before, showers should be taken before the bathing suit is put on as otherwise a thorough cleaning is not likely to be obtained. The path from the showers to the pool should be kept clean to avoid soiling the feet of the bathers. Bunker and Whipple further mention that the feet of a boy about to enter the pool were found to yield 80,000,000 bacteria.

Where suits are worn special precautions should be taken to see that they are kept clean. Only light colored suits should be permitted, since dirt may be more easily noticed on such suits and the

dye of colored suits sometimes stains the water of the pool. The suits should be washed after each use. If properly washed they will be sterile or nearly so. For the protection of the bathers the towels supplied should be as carefully washed as the suits.

In most pools a satisfactory physical examination of all bathers cannot be made and the attendant must inspect the bathers as best he can while they are entering the pool room or bathing under the showers. Any person who is suffering from a skin eruption, infection of any kind, a cough or cold should be excluded if noticed. The practice, common in men's pools, of going without the swimming suit or wearing only small triangular trunks is a help to the attendant in looking for infections, etc. The use of the expectoration trough should be required and swimmers should be told why it is objectionable for them to spit into the pool water.

Infection. It is probable that many cases of infections of various kinds have been laid unjustly at the door of the swimming pool. There are, however, a considerable number of recorded cases believed to have been due to contaminated pools and streams. Atkins (2) has divided the infections obtained by bathers in swimming pools into three classes:

1. Intestinal infections, as typhoid fever, dysentery, etc.
2. Eye and ear inflammations, like conjunctivitis, rhinitis and ethmoiditis.
3. Gonorrheal infections.

To this classification Levine (3) has rightly suggested the addition of

4. Infections of the respiratory system, like grippe, colds, pneumonia, sore throat and sinus infections.

I shall not enter into a discussion of these disorders, or of the recognized possibility of bacterial carriers infecting the water. I merely refer to the works of Baginsky (4), Cobb (5), Balduan and Noble (6), Rosenau, Lumsden and Kastlė (7), Mair (8), Burrage (9), Williams (10), Atkins (2), Manheimer (11) and many others.

The bacterial contamination of the water of swimming pools falls into two classes, the remote and the recent. The latter is of greatest importance. The pathogenic organisms are accustomed to the warmth of the body and to a profusion of food material. Thrown into the comparatively cold environment of the pool water, where food is more scarce, they die or rapidly lose their characteristics. For this reason the man who swims past you is a more real danger to you than the man who added his quota of dangerous bacteria to the pool yesterday.

Remedies. A vital question, then, becomes how best to render harmless the bacteria newly thrown off by your companions in the pool. Dilution is of great value here. A stream of fresh or purified water entering the pool with sufficient force to produce a current speedily dilutes the offensive matter and carries it to the outlet of the pool. The great dilution lessens your danger of infection.

I do not mean, however, to suggest that it is not worth our while to attempt to keep the bacterial count in our swimming pools as low as we can by the use of other agents. Where continuous dilution is not practicable chemical sterilization must, of course, be depended upon. Many of the older pools are constructed to operate on the fill-and-draw principle and have no provision for the purification and re-utilization of the water.

To my mind the re-filtration of pool water through suitable filters and the addition to the water of proper germicides offer great advantages. There is great saving in water, great saving in heat, the appearance of the water, its color and turbidity, are greatly improved and we have an abundance of purified water for dilution purposes. The capacity of the re-filtration plant ought to be sufficient to change the volume of water in the pool during the time the pool remains open except in very large pools. The San Francisco board of health requires at least 150 gallons of fresh water per user and the pool water must be changed to keep within the limit.

Where a pool is emptied one or more times a week the cost of the water required is often considerable, and when the tank is filled, the water is too cold and must be brought to the required temperature. If water can be circulated through an insulated filter, treated with alum to assist in the filtration and with some other germicidal agent to reduce the bacterial count, it can be returned to the pool with very little loss of heat, and the cost of operation is reduced to the cost of running the pump plus the cost of chemical or other treatment, depreciation and repairs. An example of this sort of saving may be seen in the following schedule of operation costs of the pool at the Evanston, Illinois, Y. M. C. A. as prepared by Mr. W. Lee Lewis of the Evanston board of health, Table 1.

Evidently the Evanston Y. M. C. A. plans to pay the same amount for the chemical sterilizer used as it did under the old system of operation. The results should, naturally, be more satisfactory.

Most swimming pool operators are agreed that refiltration of pool water is capable of effecting a money saving and in addition

renders the water clear, and of lessened color. There is less agreement as to what germicidal agent is most desirable. The necessary degree of bacterial freedom is not established. The water supplied to the swimming tank should be of good quality. Theoretically it should be kept fit to drink, because more or less water is usually taken into the nose or mouth. Relatively large amounts are often swallowed by those who are learning the art of swimming. As a matter of fact the continuous pollution and bacterial multiplication make it very difficult to maintain the water in sufficiently pure condition to recommend its use as a beverage.

TABLE 1

Comparative annual costs of operation of Y. M. C. A. swimming tank under old and new system, Evanston, Illinois

	OLD SYSTEM CHANGED ONCE A WEEK	NEW SYSTEM CHANGED ONCE IN 3 MONTHS
Cost of water, 51,980 cu. ft. in year....	$348.00	$42.00
Heating new water*..................	183.04 (52 times a year)	14.08 (4 times a year)
Power for circulating pump†..........		200.00
Total cost per year....................	$531.04	$256.08
Actual saving per year‡..............	274.96	

* Calculated for use of Pocahontas mine-run soft coal at $4.40 per ton, averaging about 14,700 B.t.u. per pound and allowing an efficiency of boiler at 60 per cent.

† Pump driven by 2-horse power motor running ten hours daily for six days in the week, fifty-two weeks per year.

‡ This apparent saving could be applied to the cost of the extra equipment needed under new system. In the case of the Y. M. C. A. this equipment cost $1,600, which can be paid for in approximately six years by the saving in cost of the new over the old method.

You will all agree with me when I say that the location of the sampling point makes a great difference in the results. Leaving out of consideration the differences in the water from different parts of the tank, we would expect to find fewer bacteria in the effluent of the purification plant than in the effluent from the pool. The real test is the quality of the pool water. And the pool water will by no means remain constant in its content of bacterial flora. Because a test showed the apparatus to be giving satisfactory purification of the water three months ago, is no proof that it is behaving as

it should today. The operator should know the condition of his pool. He should have frequent examinations made. It is contrary to good ethics to advertise that the water of a pool is better than the city's drinking water supply unless the quality of the water in the pool is actually better. The test should not be the condition of the effluent from the purification plant, because a small quantity of water of very low bacterial content may be obtained from the purifiers and that quantity may be entirely insufficient to effectively dilute the water which has been grossly contaminated.

Levine (3) has remarked that the methods used by different investigators have been strikingly unlike. The tests for gas formation have been made in dextrose and lactose broths and in lactose bile. Various combinations of gelatine and plain and lactose litmus agar have been adopted for counting the bacteria. My personal preference is for the use of litmus lactose agar at 37°C. for twenty-four hours, plain agar at 20°C. for forty-eight hours, and lactose broth in 1 and 10 cc. quantities at 37°C. The need of a standard procedure is obvious. Each sort of medium yields different numbers of colonies if kept under different conditions. For example, our counts on 20° agar plates would seem very high if they were compared with the counts on the same sort of agar incubated at 37°C. This makes it almost impossible to compare the numerical results of any two investigators.

In general it may be said that the lower the bacterial counts the more satisfactory the condition of the water. The colon bacillus should certainly be absent from the majority of 1 cc. platings. The 37°C. count should be regarded as more significant than the 20°C. count since it presumably represents the organisms that prefer the warmer temperatures and are not typical water organisms.

Disinfectants. Norton (12) and others have demonstrated that the bacterial purification effected by a sand filter is not always sufficient. Other agents are therefore employed. Those most used are copper sulphate, chlorine and its compounds and the ultra violet rays. Ozone might be used, but I do not know of an installation. On account of its demonstrated efficiency, chlorine in its various forms seems to be preferred by most health officials. The ultra-violet ray is preferred by those who have a prejudice against the use of chemicals. Copper sulphate is the choice of others who desire to avoid the odors and tastes associated with overdoses of chlorine.

It is interesting to note that Thomas (13) does not hesitate to say that calcium hypochlorite is "out of the question" for swimming pools. Levine (3) says it "cannot be employed efficiently for continuous disinfection." On the other hand Rettger and Markley (14) say that the use of copper sulphate has "fallen into disrepute" and Stokes (15) says that "in moderately polluted water, the fermentative bacteria are not destroyed" by one part of copper sulphate in 100,000 parts of water. The great number of investigators seem to have used hypochlorite and to have been successful in using it.

Regarding the poisonous properties of these chemicals, it should be said that they are both harmless within reasonable limits. The taste of either is sufficient to prevent its use in pools in sufficient quantity to be injurious. Pasteur is quoted by Kraemer (16) as saying that it is almost impossible to take a dose of copper salts large enough to cause death, both from their horrible taste and the violent vomiting produced. Kraemer reports that one observer took from 10 to 20 mgms. of copper sulphate every day for eighty days and another observer every day for fifty days without any apparent ill result. Assuming that a pool is treated with one part per million of copper sulphate and that all the copper sulphate remained in solution, which it does not, a swimmer would have to swallow from 3 to 6 gallons of pool water to get the amount of copper sulphate which these men took every day. The most incautious beginner would not swallow so much as this.

There has been some notion that the irritating effect of the small quantities of bleaching powder used in pools may be injurious, and that there may be some effect on the teeth. Roberts (17) says, however, that the occasional application of hypochlorite in small quantities and high dilutions to the mucous membranes could not be other than beneficial.

The complaints of the taste, odor and effects of hypochlorite sometimes have a humorous twist. Kellogg (18) mentions that complaints usually begin to come in before the apparatus is installed. The complaints usually come from people who have read of the installation in the papers. Injury of delicate fabrics and even bleaching of the hair are claimed at times. This play on the imagination of these people who are afraid of chemical treatment is no new thing to water works men who will remember the case of a well-known water company which received complaints of the chlorinous odor and taste of the water a full three weeks before the appara-

tus was received. We have had such complaints of our swimming pools when we had not treated the water with chlorine for three months and in fact the apparatus was in New York undergoing repairs. Dr. Newhall, of Denver, and others have written me of similar experiences with the users of pools under their supervision.

The use of ultra-violet ray treatment of swimming pool water is reported to be very efficient. Its chief draw-back is its high installation and upkeep costs. It is preferred by those who wish to advertise that the water of their pools contains no added chemical. Inasmuch as an essential feature of this treatment is thorough and repeated exposure of the water to the ultra-violet light, any turbidity in the water renders the purification less effective. For this reason it is customary to use alum treatment followed by filtration.

I have reports of occasional accidental overdosing of soft waters with alum with consequent complaints of irritation of the eyes. Although alum treatment of water is good practice, it is nevertheless a chemical treatment. The statement that the water contains no added chemical is quibbling since there is calcium sulphate in the water that was not there before the purification. The apparatus has the advantage of being practically automatic, requiring no particular skill and being free from the possibility of overdosing.

From the results of Levine (3) and Thomas (13) as well as some work of my own, I feel sure that the copper sulphate treatment of pools *can* be satisfactory. The evidence of Burrage (9), Lewis (19), Rettger and Markley (14) Lyster (20), Ravenel (21), Bunker and Whipple (1), and others, as well as our work at the State University of Iowa, convince me that *chlorination* can successfully keep a swimming pool in sanitary condition. The ultra-violet ray has shown itself capable of yielding the desired purification.

Choice of disinfectant. All of these methods, then, being satisfactory under proper conditions, the selection of the method to be applied should be based upon the character of the pool water, the prejudices of the bathers and the funds available, as well as other special conditions.

To begin with, the use of alum removes a certain amount of the alkalinity each time the water is treated. With soft waters the natural alkalinity is very soon exhausted, since it is not advisable to reduce the alkalinity to less than 5 or 10 parts per million. With such waters lime, soda ash or sodium bicarbonate must be added. The water supply which we use contains about 300 parts per million of alkalinity

and very seldom runs down below 200 parts, since we are constantly adding fresh water to replace that used in washing the filters, etc. The need of careful supervision of the addition of alum does not concern us much, locally, but the user of soft water must watch the alkalinity of his water carefully lest some undecomposed alum in the pool water cause complaints. Sedimentation basins are useful in preventing the precipitation of alum in the pool when high filter rates are employed.

Hard water containing the bicarbonates of calcium and magnesium tend to throw down the copper from copper sulphate as a precipitate, probably of the hydrate. This might give the water a bluish color and turbidity. Organic matter and free carbon dioxide tend to prevent the precipitation of the copper or to retain it longer without sedimentation. The first practical use of copper sulphate was about 1902, when Moore (22) used it for algae removal from the Virginia water-cress beds. Caird (23), Quick (24), and Bado (25) and many others have found it very efficient as an algicide. In open air pools this property is of importance in addition to the bactericidal properties. The usual method of application is to spray a solution of copper sulphate on the surface of the pool, or to put a weighed amount of the crystals in a bag which is thrown into the pool to be dived for or dragged around the pool until the crystals are dissolved.

In some experiments of ours at a time when our chlorinators were out of commission I used a different procedure. I added the copper sulphate with the alum before the water entered the filter. Ellms in 1905 (26) reported that he had used this method with success and claimed that the increased concentration of the copper on the surface of the filter was advantageous. About the same time Clarke (26) at Lawrence had tried similar experiments with the experiment station filters and reported that the efficiency of the filters was slightly reduced. It should be remarked that the filters Ellms used were mechanical and those that Clarke used were of the slow sand type. The lessened efficiency in the latter case was due to the interference with the biological processes in the slow sand filter. Some German experimenters have claimed that most of the spore-forming bacteria are killed in passing through a sand bed whose top layers show a considerable concentration of precipitated copper.

Results. In our experiments we found that, compared with the

ratio when chlorination was used, the copper sulphate was more efficient in destroying the organisms growing at 20°C. than in destroying those growing at 37°C. While our counts at 37°C. did not go above 500 per cubic centimeter, nevertheless a greater percentage approached 500 than when we used chlorine. We used only about one-fifth of a part in 1,000,000 of copper sulphate per day, but that amount seemed quite effective. In comparing these results with Levine's (3) it should be remembered that his counts are 37°C. counts taken at the deep end of the pool, while our counts were made at 37° and 20°C. and were taken at the shallow end only a few feet from the inlet.

During this year, it is our plan to alter our practice somewhat by taking samples midway of the pool, while repeating enough tests from time to time under the old system to keep the results comparable, and in addition to take direct samples of the purified water.

The literature on calcium hypochlorite is extensive. Its use was given wide publicity by Jennings in 1908 (27) although the use of hypochlorite and similar compounds had been tried before with success. A survey of the method by Johnson (28) will be found interesting. Burrage (9) used hypochlorite at Purdue in 1910 to purify the swimming pool water. His method was to sprinkle the powder directly onto the surface of the pool water and allow the powder to sink. This method is unsatisfactory, since the tell-tale odor of the powder remains in the room, which renders it objectionable to the bathers. Some powder also remains on the surface, which is unsightly and likewise objectionable from the local concentration of odor and taste. Dragging the powder enclosed in a bag over the surface of the water is objectionable for like reasons. If the bag be weighted the objectionable odor in the room is eliminated. It has been suggested by Bunker (29) that the best way of applying the powder is to draw the weighted bag through the water by a series of sharp jerks. At each jerk a little cloud of the powder is thrown into the water at the bottom of the pool. Of course, javel water or a suspension of the hypochlorite may be injected into the circulation system of the pool.

Buswell (30) tried to avoid the odor of the chlorine and the inaccuracies of administration at Columbia University by adopting the use of a saturated solution of chlorine in water. The solution was prepared by bubbling chlorine gas through a series of 5 gallon bottles of water.

It may be that a given excess of chlorine is objected to more earnestly in a pool because of the large quantity of water and the persistence of the heavy odor of chlorine. Salt in a water serves somewhat to disguise the objectionable taste. Roberts (17) suggested the use of enough common salt to render the water of a pool a solution of about 0.9 per cent salt, usually called a physiological salt solution, urging the disguising of the odor of the germicide. The only organization that I know of which adds salt to the water of the pool is the Deseret Gymnasium at Salt Lake City, Utah.

In using liquid chlorine with the usual apparatus at the State University of Iowa, we tried at first to add the gas continuously and very slowly. This was not successful. We then added the chlorine in larger doses, early in the evening and treated with a rather large dose on Saturday night. This procedure was quite successful in reducing the trouble. We cannot give the exact rates used because the quantities involved were very small and we had no platform scales.

The results shown in table 2 are the range of bacterial counts on the two state university pools. They are reported according to the number of days on which the counts fell into certain numerical groups.

TABLE 2

Tests at the swimming pools of the State University of Iowa

POOL	CONDITIONS	RANGE OF BACTERIA LITMUS LACT. AGAR.						RANGE OF BACTERIA NUTRIENT AGAR							GAS FORMERS, DAYS IN 1 C. C.	ACID COLONIES, DAYS IN 1 C. C.
		DAYS 0 PER C. C.	1–10 PER C. C.	11–50	51–100	101–500	NO. PLATINGS	DAYS 1-100 PER C.C.	101–500	501–1000	1001–10,000	10,001–20,000	20,001–30,000	NO. PLATINGS		
Women's	Filter alone	1	17	5	0	1	24	3	7	5	7	3	1	26	3	1
	Filter and Cl	7	20	9	1	5	42	0	3	1	24	10	7	45	0	0
	Filter and $CuSO_4$	0	2	11	5	61	79	1	0	0	34	27	20	82	0	0
Men's	Filters alone	1	23	2	0	0	26	0	4	4	13	6	2	29	7	2
	Filters and Cl	16	19	5	4	1	45	0	0	4	20	11	10	45	0	0
	Filters and $CuSO_4$	2	11	8	10	47	78	0	0	1	49	23	11	84	0	0

Period covered, January 27 to August 24, 1916.
Women's pool emptied May 19, 1916; men's, May 27, 1916.

TABLE 3

Swimming pools

STATE	CITY	MAINTAINED BY	CAPACITY	GALLONS PER USER PER DAY	DIMENSIONS: Length	DIMENSIONS: Width	DIMENSIONS: Maximum depth	DIMENSIONS: Minimum depth	TEMPERATURE °F	TIMES EMPTIED AND CLEANED	PURIFICATION PROCESSES: Filters	Alum	Chlorine	Calc. Hypochl.	Copper sulph.	Ultra-violet ray	Other	USERS PER DAY	SOURCE
			gallons		ft.	ft.	ft.	ft.											
Alabama.........	Mobile	Y. M. C. A.			50	22	6	4	70	Once a wk.							Circulation	150	City
California........	Berkeley	U. of C. (Men)	650,000	3,250	232	76	10	3	65–68	4 times year				+			Circulation	200	City
California........	Berkeley	U. of C. (Women)	131,000	749	75	40	$8\frac{3}{4}$	3	70–72	4 times year				+			Circulation	175	City
California........	Palo Alto	Stanford (Men)	230,000	2,300	100	40	9	$3\frac{1}{2}$	60–72	Every 3 wks.	+	+		+	+		Open air	100	Stream
California........	San Francisco	Lurline Baths	325,000		140	65	9	2	79–80	2–4 times wk.	+						Electro-chlor.		Ocean
California........	San Francisco	Y. M. C. A.	115,000	144	85	25	9	$3\frac{1}{2}$	72	2 times wk.			+					800	Ocean
Colorado.........	Denver	Y. M. C. A.	55,000	157	60	20	$8\frac{1}{8}$	$3\frac{1}{2}$	80	4 times yr.	+	+		+				350	City
Connecticut......	New Haven	Yale University	150,000	400	75	30	11	$5\frac{2}{3}$	78	1 time week				+				350–400	Well
Connecticut......	Waterbury	Y. M. C. A.	33,000	189	40	18	$6\frac{1}{2}$	$2\frac{1}{2}$	70	4–6 times yr.	+	+						150–200	City
Illinois...........	Chicago	Cent. Y. M. C. A.	65,000	173	66	22	$8\frac{1}{2}$	$3\frac{1}{2}$	75	Every 1–2 dys.	+							250–500	City
Illinois...........	Chicago	Div. St. Y. M. C. A.			60	25	8	3	72–75	Every 3 days	+	+						135	City
Illinois...........	Chicago	Y. M. C. A. Col.			60	24	7	6	78	Every 2–3 dys.	+	+						100	City
Illinois...........	Evanston	Y. M. C. A.	76,000	506	60	25	$8\frac{1}{2}$	$3\frac{1}{2}$	76		+	+		+				150	City
Illinois...........	Peoria	Y. M. C. A.	62,000	620	60	20	$8\frac{1}{2}$	$3\frac{1}{2}$	78	4 times yr.	+			+				100	City
Illinois...........	Rock Island	Y. M. C. A.	60,000	240	60	20	$7\frac{1}{2}$	3	75–82	4–12 times yr.	+	+		+				200–300	City
Indiana...........	Evansville	Y. M. C. A.	75,000	300	75	25	$7\frac{1}{2}$	$3\frac{1}{2}$	84	2 times wk.								250	City
Indiana...........	Indianapolis	Y. M. C. A.	58,000	580	60	20	$8\frac{1}{2}$	$4\frac{1}{2}$	68–70	2 times wk.				+				100	City
Indiana...........	South Bend	Y. M. C. A.			60	24	$8\frac{1}{2}$	$3\frac{1}{2}$	75	1 time wk.				+				100	City
Iowa.............	Ames	Ia. State Col.	90,000	900	60	30	$7\frac{2}{3}$	3		Irreg.	+				+			<100	City
Iowa.............	Burlington	Y. M. C. A.	60,000	1,500	60	20	$8\frac{1}{2}$	$3\frac{1}{2}$	76–89	1 time wk.	+	+						25	City
Iowa.............	Cedar Falls	St. Teachers	48,000	240	55	20	6	4	78–82	1 time wk.					+			200	City
Iowa.............	Cedar Rapids	Y. M. C. A.	50,000	250	49	20	7	4		1 time wk.				+				200	City
Iowa.............	Clinton	Y. M. C. A.	24,000	320	$33\frac{1}{2}$	$17\frac{5}{6}$	$7\frac{1}{2}$	$4\frac{1}{2}$	78	1 time wk.				+	+			75	City

Iowa	Council Bluffs	Y. M. C. A.	20,000	571	40	15	7	3½	78	2 times wk.								35	City
Iowa	Davenport	Y. M. C. A.	55,000	200	60	20	7½	3	80	6–9 times yr.	+	+			+			100–450	City
Iowa	Des Moines	Y. M. C. A.	54,000	164	60	20	8	4	78	3 times wk.				+				204–455	City
Iowa	Des Moines	East D. M. H. S.			40	20	7½	4	Irreg	2 times wk.	+	+						25–100	City
Iowa	Dubuque	Y. M. C. A.	48,000		60	18	8½	3½		Irreg.	+	+		+					City
Iowa	Ft. Dodge	Y. M. C. A.	35,000	255	60	18	8½	3½	72–80	2 times wk.					+			125–150	City
Iowa	Iowa City	I. C. High School	25,000	1,667	40	20	5	3½		2 times wk.				+				15	City
Iowa	Iowa City	S. U. I. (Men)	89,100	445	60	30	8	4	76	3–4 times yr.	+	+	+		+			200	Well
Iowa	Iowa City	S. U. I. (Women)	61,200	254	60	24	7⅘	3 9/10	84	3–4 times yr.	+	+	+		+			225	Well
Iowa	Keokuk	Y. M. C. A.	55,000	315	51	23	8	4	75–82	2 times wk.								150–200	Well
Iowa	Ottumwa	Y. M. C. A.	45,000	300	50	24	7½	4½	80	1 time wk.				+				150	Well
Iowa	Sioux City	Y. M. C. A.	8,547	85	30	12	6	3	76	2 times wk.								100	City
Iowa	Waterloo	Y. M. C. A.	40,000	267	40	20	6½	4	70–76	2 times mo.								150	City
Kentucky	Louisville	Y. M. C. A.	97,000	277	75	30	8	4	76–80	1–2 times wk.	+	+		+				300–400	City
Kansas	Lawrence	U. of K.	50,000	333	50	20	8	8	76–78		+							100–200	City
Maryland	Annapolis	U. S. N. Acad.	160,000	400	80	60	5⅛	3⅔	72–75	2 times mo.	+		+					400	Well
Massachusetts	Cambridge	Y. M. C. A.	45,000	300	60	20	7½	3½	72	2 times yr.	+				+			150	Well
Massachusetts	Springfield	Int. Y. M. C. A. Col.	75,000	250	60	24	8	4	68–75	1 time yr.	+	+		+	+			300	Well
Massachusetts	Springfield	Y. M. C. A.			75	25	7	3½	74		+	+				+		200	City
Michigan	Ann Arbor	U. of M. (Women)					5	3½	70–74	Every 3 wks.				+			Circulation	10–40	City
Michigan	Detroit	Y. M. C. A.	100,000	333	75	30	8	5	76	Every 3 wks.	+	+				+		300	City
Michigan	Grand Rapids	Y. M. C. A.	53,000	265	60	22	8	3½	75–80	Every 3 mo.	+	+			+			200	City
Minnesota	Minneapolis	Y. M. C. A.	30,000	120	35	20	5½	4½	72–75	2 times wk.				+				250	City
Minnesota	St. Paul	Church Club	52,000	963	50	25	8	3	78	6 times yr.	+	+			+			54	City
Minnesota	St. Paul	Wilder Baths	90,000	189	70	30	8	4	78	2 times wk.	+			+				460	City
Minnesota	St. Paul	Y. M. C. A.	80,000	457	75	25	8	4½	72–74	2 times wk.					+			175	Well
Missouri	Columbia	U. of Mo.	40,000		50	20											"Antiseptic"		City
Missouri	Kansas City	Y. M. C. A.	35,000	187	45	20	7	3½	76–80	3–24 times yr.	+	+		+				75–300	City
Missouri	St. Louis	St. Louis U.			100	50	20	4		2 times wk.								100	City
Missouri	St. Louis	Cent. Y. M. C. A.	58,000	290	69½	22	6½	4	76–80	1–3 times wk.				+				200	City
Nebraska	Omaha	Y. M. C. A.			60	20	8	3½	78	2–3 times wk.								100–125	Well
New York	Buffalo	Cent. Y. M. C. A.	54,000	270	60	20	8	4	74		+	+		+				200	City
New York	New York	Coll. City, N. Y.	125,000	139	100	28	8	5	74	1 time wk.	+							900	City
New York	New York	23d St. Y. M. C. A.	55,000	183	48	24	7½	4½	65–70	1 time wk.								300	City
New York	New York	W.side Y. M. C. A	60,000	100	60	21	8½	5	74	2–3 times yr.	+	+				+		600	City
Ohio	Cincinnati	Y. M. C. A. (old)			40	18	6	3	70–78	3 times wk.								100–300	City

TABLE 3—*Concluded*

STATE	CITY	MAINTAINED BY	CAPACITY	GALLONS PER USER PER DAY	DIMENSIONS: Length	DIMENSIONS: Width	DIMENSIONS: Maximum depth	DIMENSIONS: Minimum depth	TEMPERATURE °F	TIMES EMPTIED AND CLEANED	PURIFICATION PROCESSES: Filters	PURIFICATION PROCESSES: Alum	PURIFICATION PROCESSES: Chlorine	PURIFICATION PROCESSES: Calc. hypochl.	PURIFICATION PROCESSES: Copper sulph.	PURIFICATION PROCESSES: Ultra-violet ray	PURIFICATION PROCESSES: Other	USERS PER DAY	SOURCE
			gallons		*ft.*	*ft.*	*ft.*	*ft.*											
Ohio.............	Cleveland	Case S. A. S.			60	29	8	4	76–78	2–3 times mo.	+	+	+					<100	City
Ohio.............	Cleveland	Cent. Y. M. C. A.	85,000	188	75	25	8	4	76	1 time wk.	+	+		+				400–500	City
Ohio.............	Columbus	O. S. Univ.			40	20	6	3	76	Daily								400	City
Ohio.............	Columbus	Y. M. C. A.	50,000	250	58	18	6½	2½	78	3 times wk.				+				200	City
Ohio.............	Dayton	Y. M. C. A.			60	24	7½	4	78	6 times yr.	+	+				+		200	Well
Ohio	Toledo	Y. M. C. A.	50,000	333	60	20	7	4	80	1 time wk.				+				150	City
Pennsylvania.....	Philadelphia	Cent. Y. M. C. A.	96,000	320	75	25	8½	4½	76	1 time mo.	+				+			300	City
Pennsylvania.....	Pittsburgh	E. Liby.Y.M.C.A.	60,000	240	60	30	8½	3½	76	1–2 times wk.				+				250	City
Pennsylvania.....	Pittsburgh	Hilltop Y.M.C.A.					8½	3½	76	3 times wk.	+	+						60	City
Pennsylvania.....	Pittsburgh	Lawrenceville Y.	50,000	500	60	20	7½	4½	76–78	1 time wk.							"Chemicals"	100	City
South Carolina...	Charleston	Y. M. C. A.	67,265		60	20	8	4	79–84	1 time wk.	+	+		+				—	City
Texas............	Galveston	Y. M. C. A.	25,000	250	37	20	11½	4	—	2 times wk.					+			100	City
Utah.............	Salt Lake City	Deseret Gym.	88,000	147	60	30	8½	5½	78	1 time wk.	+			+			Salt	600	City
Virginia..........	Richmond	Y. M. C. A.	40,000	200	60	20	7	4	68	2–3 times wk.	+	+		+				200	City
Washington.......	Spokane	S. A. A. Club			44	20	8	3	68	3 times wk.								100	City
Washington.......	Spokane	Y. M. C. A.	35,000	171	48	18	7½	3	75	2 times wk.								50–300	City
Wisconsin.........	Appleton	Y. M. C. A.	50,000	500	60	20	7½	3	74	4 times yr.	+	+		+				100	City
Wisconsin.........	Menomonie	Stout Inst.	100,000	2,000			8	3	78						+		Circulation	50	Well
Nova Scotia......	Halifax	Y. M. C. A.	27,000	216	40	18	8	4	74	1 time wk.				+				50–200	City
Ontario...........	Montreal	Y. M. C. A.	80,000	229	75	25	9	4	70	1 time wk.	+							350	Well
Ontario...........	Ottawa	Y. M. C. A.	30,000	120	40	18	8	4	68	1 time wk.							Half-filled daily	250	City
Quebec...........	Quebec	Y. M. C. A.	56,000	1,400	50	25	8	3	70	1–2 times wk.								40	City

Note.—A preliminary shower bath is required at each of these pools.

The test with the filter alone should really not be compared with the two other tests since the pools were filled the first time near the end of the first semester and were used only by the instructors until a few days before chlorine treatment commenced. You will note, however, that gas and acid formers were in the pool water. Then note that there were no gas and acid forming bacteria found on 1 cc. quantities during the period when we were using copper sulphate and liquid chlorine. At the present time, still using copper sulphate because our chlorinators are not connected as yet, we are finding no gas formers in 10 cc. of pool water.

General practice. Within the last two months I have been sending out questionnaires relating to swimming pool practice. I was especially anxious to know what methods of purification were used, what temperature was maintained and how many gallons of water each pool contained for each user in a single day. Table 3 contains the data for 81 pools.

A survey of this data shows the following:

Pools reporting	81	
Pools using filters	41	
Pools using filters and alum	29	
Pools using liquid chlorine	5	38
Pools using calcium hypochlorite	33	
Pools using copper sulphate	16	
Pools using chlorination and copper sulphate combined	5	
Pools using ultra-violet rays	4	
Pools using no treatment	13	
Average temperature	75.7°F.	
Average capacity	77,000 gallons	
Average number users in 1 day	214	
Average number gallons per user first day	486.3 gallons	

SUMMARY

1. The construction of a swimming pool should render it easy to clean the pool and its surroundings and to keep them in that condition.

2. The convenience of the users should be considered and it should be made easy for them to do their part in keeping the pool sanitary.

3. Users should be inspected and required to bathe thoroughly; to avoid coughing, spitting and urinating in the pool, and to avoid the carrying of dirt of any sort into the water upon their persons.

4. Suits if worn, should be light-colored and should be kept clean.

5. There is need of some reasonable bacterial standard for pool water and there should be a more uniform analytical procedure as well.

6. The fresh, vigorous bacteria newly thrown off by your neighbors in the pool are most dangerous to you. They can be rendered less dangerous by rapidly diluting the polluted water with fresh or re-purified water.

7. Re-filtration effects a considerable saving in water and heat and supplies a clear water. It is not satisfactory for providing a sufficiently pure pool water.

8. Copper sulphate, chlorination and the ultra-violet ray are capable of purifying the water.

9. The ultra-violet ray apparatus is expensive to purchase and operate.

10. Chlorination has been more efficient than copper sulphate in our experiments, and is more widely used.

11. Copper sulphate is employed to avoid the odor and taste of the chlorine compounds.

I wish to acknowledge the assistance of Harold Barber and Frank Kennan, who have carried out the operation of the purification devices and the examination of the water of the pools at the State University under my direction.

REFERENCES

(1) Bunker and Whipple: Amer. Phys. Ed. Rev., **18,** 75 (1913).
(2) Atkins: Proc. Third Meeting, Ill. Water Supply Assn. (1911) p. 72.
(3) Levine, J.: Infect. Diseases, **18,** 293 (1916).
(4) Baginsky: Hyg. Rundschau **6,** 597 (1896).
(5) Cobb: Boston, Med. and Surg. Journ., **159,** 9 (1908).
(6) Balduan and Noble: J. Am. Med. Assn., **58,** 7 (1912).
(7) Rosenau, Lumsden and Kastle: Bul. 52, U. S. P. H. S. (1909).
(8) Mair: Proc. Roy. Med. Soc., **2,** 227 (1908).
(9) Burrage: Eng. News, **63,** 740 (1910).
(10) Williams: Med. Record, **79,** 1039 (1911).
(11) Manheimer, Am. Phys. Ed. Rev. **17,** 667 (1912).
Manheimer: Reprint No. 299, U. S. Pub. Health Reports
Manheimer: J. Infect. Dis. **15,** 159, (1915).
(12) Norton: Am. J. Pub. Health, **4,** 106.
(13) Thomas: J. Industrial and Eng. Chem. **7,** 496 (1915).
(14) Rettger and Markley: Eng. News, **66,** 636 (1911).

(15) STOKES: Amer. Med. **10,** 1075 (1905).
(16) KRAEMER: Am. J. Pharm, **77,** 265 (1905).
(17) ROBERTS: Eng. News, **67,** 73 (1912).
(18) KELLOGG, U. S. Pub. Health Reports **29,** 687 (1914).
(19) LEWIS: Eng. News, **63,** 740 (1910).
(20) LYSTER: J. Am. Med. Assn., **57,** 1992 (1914).
(21) RAVENEL: Am. Phys. Ed. Rev. 17, 684 (1912), Also in 6th Cong. Am. School Hyg. Proceedings.
(22) MOORE: Am. J. Pharm., **76,** 553 (1904).
(23) CAIRD: Eng. News **52,** 34 (1904).
(24) QUICK: Eng. News **52,** 283 (1904).
(25) BADO: La Accion del Sulfato de Cobre, Buenos Aires, (1916).
(26) SYMPOSIUM: Journ. N. E. Water Wks. Assn. **19,** 474 (1905).
(27) JENNINGS: Eng. Record, **62,** 321 (1910).
(28) JOHNSON: Eng. Record, **62,** 340 (1910).
(29) BUNKER: Am. J. Pub. Hyg. **20,** 810 (1910).
(30) BUSWELL: Am. Phys. Ed. Rev. **18,** 395 (1913).
(31) HINMAN: Eng. Contrg. **46,** 135 (1916).